the Grand Junction Company's shaft, on the eastern side of the range, it also occurs as boulders in the drift, and contains quartz pebbles, having no doubt been washed down from the reef in middle pliocene times. It contains gold in itself, and was being saved for crushing. Is it possible that these carbonaceous selvages to reefs have had any influence on or been the cause of the formation and segregation of gold in the reefs? Although much has been done by Mr. J. Cosmo Newbery towards a solution of this question, but with at present rather unsatisfactory results, still a great deal yet remains to be accomplished before an answer can be given to this important question.

Art. XI.—*Notes on Small Motors.*

By W. C. Kernot, M.A., C.E.

[Read October 9th, 1879.]

The general substitution of machinery for hand-labour in various industries during modern times has given to the question of prime movers an importance it did not possess in earlier periods, and has led to the perfecting of old and development of new expedients for obtaining mechanical power. Amongst these expedients the steam engine holds by far the most prominent place, while the various hydraulic motors, though of somewhat infrequent occurrence in the dry climate of Australia, are of inestimable value in localities where a constant fall of water is available.

But while the demand for motive power is very fairly met in the case of transport by land and sea, and of large establishments when numerous or comparatively heavy machines have to be kept in motion, it will, I think, be freely admitted that an important, and, as yet, but imperfectly occupied field remains for a cheap, simple, and easily managed motor of small power. We need a suitable contrivance for working small lathes, lapidaries' wheels, dental engines, sewing machines, grindstones, &c., for winding up large clocks, and for actuating various pieces of mechanism which are beginning to make their appearance in our private residences; in short, a cheap and convenient motor for the small industries and for scientific and domestic purposes is undoubtedly one of the needs of the day.

This need has for some years past been recognised by mechanicians, and various machines have been devised, none of which, however, have been generally adopted. Amongst these may be mentioned diminutive steam engines, electro-motors, hot-air engines, and gas engines. The first of these are open to several serious objections. They are complex and delicate, need much attention, and, worst of all, are deficient in readiness, the process of getting up steam taking considerable time.

Electro-motors are simple in construction, and not easily deranged. The battery is here the objectionable feature, being a continued source of expense and trouble, and requiring the use of materials the presence of which is, to say the least, by no means desirable in the kitchen or larder.

Hot-air engines compare favourably with the preceding in most respects. They, however, are bulky and rather expensive, and need a fire continually maintained beneath them. The attention this fire requires and the waste heat radiated from it are objectionable, especially in small workshops and during warm weather.

Gas engines of from one to ten horse-power are very much in favour at present, and bid fair to supplant many of the smaller steam engines, especially in positions when the question of insurance is paramount. They are exceedingly convenient, being always ready, and needing no attention beyond lubrication. In first cost they are, however, very expensive, and all that I have yet seen are far too large for the purposes at present under consideration.

There is one source of power usually present in important towns which has yet to be noticed. In our street-mains we have a large supply of water under a considerable pressure, and capable of doing work to a corresponding extent; and if a suitable hydraulic motor can be found it is evident that we have here a source of power which for readiness and convenience can hardly be surpassed. This power has already been generally adopted for the purpose of working the bellows of large organs, but beyond this its application has hitherto been very limited.

To utilise the energy of the water is the question now before us, and for this purpose several kinds of motor are available. The ordinary piston and cylinder is very well suited when a comparatively slow motion is needed, as in organ blowing, but is not so applicable when a rotary motion at a comparatively quick speed is desired. For such a purpose a turbine appears more promising; and it is next necessary to decide which of the various forms of turbine should be adopted. When used on a large scale, and with an ample supply of water, the merits of outward flow, parallel flow, inward flow, and reaction turbines appear very nearly balanced, the first cost not differing largely, and the efficiency lying between 60 and 80 per cent. in each case. But when the problem is to make the most of a very small stream of water at a pressure of not less than 50 lbs. per square inch, outward, parallel, and inward flow turbines need to be made of proportions, and to run at speeds which are practically objectionable. Wheels of not more than $1\frac{1}{2}$ inches in diameter, running at speeds of considerably over 5000 revolutions a minute, do not appear by any means desirable in a domestic motor, and hence we are led, as a last resource, to adopt the oldest form of all—the reaction wheel. With this we find it is possible to combine a comparatively large radius with a jet of the requisite dimensions, and thus obtain a machine the economical working speed of which is not impracticably high.

The reaction wheel has been known as a motor since exceedingly early times, and a rude form of it actuated by steam constituted the well-known *æolipyle*, or rudimentary steam engine of Hero, of Alexandria, B.C. 130. In a somewhat crude shape, adapted for water, it forms part of the apparatus of the physical lecturer, and is known as "Barker's Mill" (fig. 1). Of late years the questions of its economic speed and highest efficiency have been investigated mathematically and experimentally, and have led to its adoption on a large scale.

The following is a summary of our knowledge on the subject:—

1. With a perfect or frictionless fluid the efficiency of the reaction wheel increases toward unity as its angular velocity increases without limit.

2. In a well formed reaction wheel worked by water the best speed is approximately that at which the linear velocity of the jet is equal to $8\sqrt{h}$ where h is the head of pressure.

3. That at this speed an efficiency of fully 75 per cent. has been attained.

4. That in order to attain a good result, sharp bends and sudden changes in velocity of flow should be avoided, and

the passages so formed as to have as large a *hydraulic radius* as possible.

Fig. 2 represents a form of reaction wheel devised by the writer of this paper, and which is thought to fulfil the above conditions more perfectly than any hitherto adopted. There are no abrupt bends. The velocity of flow gradually increases in the tapered pipe, attaining its maximum at the terminal jet, and by adopting a circular section throughout, and having but one jet instead of two or more, as in previous forms, the *hydraulic radius* is kept as large as possible.

In the case of every hydraulic motor supplied with water through a pipe, there is a certain *critical velocity* of flow in the pipe at which the maximum development of power will take place. If the velocity be less than this, the power will be reduced and the efficiency of the system somewhat increased. In other words, the quantity of water expended will be reduced in a higher ratio than the power. If the critical velocity be exceeded, the expenditure of water will be enhanced, but both power and efficiency reduced. Adopting Darcy's views as to the friction of water on the walls of the pipe, this critical velocity can be shown by the aid of the differential calculus to be ·575 of the full velocity when the pipe is discharging freely, and at this speed one-third of the total head of the water will be employed in overcoming friction in the pipe, and the remaining two-thirds be available for the production of motive power.

The motor shown (Fig. 2) has been successfully applied to driving a small lathe for turning either wood or metal. At the outset, however, it was found that with such an irregular resistance as that of turning, inconvenient variations of speed took place, and water was wasted when the wheel was racing. This defect was partly remedied by the use of a fly-wheel, but was eventually more thoroughly obviated by means of a jet, the dimensions of which were altered by the centrifugal action of a weight, which, with its opposing spring, was so adjusted as to form an approximately isochronous system. The mechanical details of this contrivance are shown in Fig. 3.

The following tabulated statements show—1. The particulars and results of experiments to determine the power and efficiency of the motor; 2. The comparative cost of motive power per 1,000,000 ft. lbs., as derived from various sources; and 3. The approximate power required in order to perform several of the functions of a small motor.

PARTICULARS OF EXPERIMENTS.

Time, nine p.m.
Height above sea, 130 feet.
Hydrostatic pressure by gauge, 75 lbs.
Free discharge of pipe, 11·7 gals. per minute.
Radius of turbine, $4\frac{1}{4}$ inches.
Best speed, 1300 revolutions per minute.
Greatest power of turbine, 1800 ft. lbs. per minute.
Consumption of water, 2·8 gals. per minute.
Efficiency, 40 per cent.

This comparatively low efficiency is probably due to the small size and rude construction of the machine; on a somewhat larger scale and well made it may reasonably be expected to give at least 50 per cent.

When all the machinery was disconnected the expenditure of water was reduced by the automatic closing of the jet to ·75 gals. per minute.

A similar experiment was tried with the jet fixed open, when the turbine increased its speed to about 2000 revolutions a minute, and discharged considerably over 3 gals. per minute.

Comparative Cost of Motive Power, as Derived from Various Sources, *the Price of Coal, Labour, and Gas in Melbourne being taken as a basis of computation.*

	Pence.
1. Large marine engines of the most modern type, per million ft. lbs.	·20
2. Stationary condensing engines of less than 100 indicated horse-power	·35
3. Non-condensing stationary engines of less than 50 indicated horse-power	·45
4. Large gas engines of the most improved type	·90
5. The above-mentioned turbine, as tested (water at 1s. per 1000 gals.)	18·5
6. Manual labour at a crank-handle	55·0

Power Required to Perform Several of the Functions of a small Motor, and Corresponding Cost of Water for the Turbine, *under the same conditions as to Pressure, &c., as those obtaining during the experiments.*

	Foot Pounds of Work per Minute.	Cost of Water per Hour.
		Pence.
Supplying wind to a small organ of 6 stops, using full organ	372	·41
Driving an ordinary sewing-machine...	416	·46
Turning a 16-in. grindstone for grinding carpenters' tools	2000	2·22
Driving a foot-lathe, turning wood or metal, average work	1350	1·50
	Foot Pounds per Annum.	Cost per Annum.
Winding-up a large turret-clock, such as that at the Richmond Town Hall	8,000,000	12/4

Art. XII.—*On the Yarra Dialect and the Languages of Australia in connexion with those of the Mozambique and Portuguese Africa.*

By Hyde Clarke,

Vice-Pres. Anthropological Institute; Vice-Pres. Statistical Society; Vice-Pres. Society of Arts; Cor. Mem. American Oriental Society; Mem. German Oriental Society; Hon. Mem. American Anthropological Institute; Hon. Mem. Byzantine Society of Constantinople; Cor. Mem. Ethnographic Society of Paris; Cor. Mem. Congress of Pre-historic Archæology; F. R. Soc. of Antiquaries of the North, of Copenhagen; F. R. Historical Soc.; F. R. Colonial Institute; Fellow Philological Society.

[Read November 13th, 1879.]

In Mr. R. Brough Smyth's great work, *The Aborigines of Australia* (Melbourne, 1878), there will be found in the second volume much matter on the languages of Australia. Among these will be found a very long vocabulary of the Yarra dialect, of the Yarra River, of Melbourne, composed by Mr. John Green, Inspector of Aborigines.